**A DISSERTION ON**

# OPTIMIZE QUALITY OF SERVICE

# OF

# NETWORK SERVICE PROVIDERS

*Submitted in Partial fulfilment of the Requirements*

*For the award of the degree of*

**MASTER OF TECHNOLOGY**

**IN**

**SOFTWARE TECHNOLOGY**

**DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING**

*SUBMITTED BY*

YOGESH LAKHERA
ROLL NO: 2K13/SWT/20

**UNDER THE ESTEEMED GUIDANCE OF**

**MR. RAJESH KUMAR YADAV**

**ASSISTANT PROFESSOR, CSE DEPARTMENT, DTU**

**DEPARTEMENT OF COMPUTER SCIENCE & ENGINEERING**

**DELHI TECHNOLOGICAL UNIVERSITY,**

**DELHI-110042, INDIA**

DELHI TECHNOLOGICAL UNIVERSITY

NEW DELHI

# DECLARATION

I hereby undertake and declare that this submission is my original work and to the best of my knowledge and believe, it contains no material previously published or written by another person nor material which has been accepted for the award of any other degree or diploma of any Institute or other University of higher learning, except where due acknowledgement has been made in the text. Project work mentioned in thesis is well discussed and improved under the guide supervision.

DATE:

SIGNATURE: YOGESH LAKHERA

ROLL NO: 2K13/SWT/20

DELHI TECHNOLOGICAL UNIVERSITY

NEW DELHI

# CERTIFICATE

This is to certify that the thesis entitled, "**OPTIMIZE QUAITY OF SERVICE OF NETWORK SERVICE PROVIDERS**", is a bona fide work done by Mr. Yogesh Lakhera in partial fulfilment of requirements for the award of Master of Technology Degree in software technology at Delhi Technological University (New Delhi) is an authentic work carried out by him under my supervision and guidance. The matter embodied in the thesis has not been submitted to any other University / Institute for the award of any Degree or Diploma to the best of my knowledge.

DATE:

SIGNATURE

MR. RAJESH KUMAR YADAV
Assistant Professor, Department of CSE,
Delhi Technological University

# ACKNOWLEDGMENT

I am presenting my work on "**Optimize Quality of Service of Network Service Provider's**" with a lot of pleasure and satisfaction. I take this opportunity to thank my supervisor, Prof. R. K. Yadav, for guiding me and providing me with all the facilities, which paved way to the successful completion of this work. This thesis work was enabled and sustained by his vision and ideas. His scholarly guidance and invaluable suggestions motivated me to complete my thesis work successfully. I would like to express my deep gratitude to my parents. Their continuous love and support gave me strength for pursuing my dream. I am thankful to my friends and colleagues who have been a source of encouragement and inspiration throughout the duration of this thesis. I am also thankful to the SAMSUNG who has provided me opportunity to enrol in the M. Tech program and to gain knowledge through this program. This curriculum provided me knowledge and opportunity to grow in various domains of computer science. Last but not least, I am thankful to all the faculty members who visited the Samsung premises to guide and teach. I feel proud that their contribution helped me to bring out new ideas in my professional life. This project has provided me knowledge in the area of Quality of Service parameters for Service providers and consumer experience based upon the quality standards. I have given ample time and guidance to complete my project under timeline defined by the university. This project has given me opportunity to explore the domain of mobile communication



YOGESH LAKHERA,<br>
ROLL NO: 2K13/SWT/20

# ABSTRACT

In today's world we all are connected and are communicating with each other with latest technologies be it wired or wireless network For Example PSTN, Bluetooth, Wi-Fi, Mobile communications

Mobiles communications is accepted as widely used technology across the world for communications the customers has the advantage to move while being connected through voice service or the data service

Mobile communications is dependent on various factors both the Handsets a well as the Service provider infrastructure need to communicate at the background so called the protocols so that the customer can get the seamless experience of the services. There are various challenges to be associated while providing the services these factors are simply termed as Quality of Service. Service providers in the given telecom circle needs to maintain the QoS level if not customers can complain and can move to another service provider resulting in loss of business

Recently in India The Department of Telecommunication (DoT) has asked all mobile phone-service providers to submit a report on action taken by them to address the call drop, The letter said it was necessary that service providers undertook a special drive for radio frequency optimization, analyse the reasons for call drops and take appropriate steps such as installation of more sites, adopting in-building solutions, augmenting existing radio frequency resources as the case might be.

In my case study i will be discussing various ways to measure the Telecom Service Provider capability by doing various tests static as well as dynamic in nature, which further can give feedback to Telecom Service Provider to optimize in particular cell/Area

Lastly my objective is to identify failure causes from Telecom Service Provider side and feedback to the service provider to improve the same for enhancing consumer experience

# Contents

# LIST OF TABLES



# LIST OF FIGURES

# Chapter 1: Introduction

Communication has become must in the present world and hence handsets are equally important when we discuss wireless, further various standards & factors are discussed in detail to provide overview

## 1.1 Mobile Communications Standards

GSM (Global System for Mobile Communications, is a standard developed by the European Telecommunications Standards Institute (ETSI) to describe the protocols for second-generation (2G) digital cellular networks used by mobile phones ([1]P. Stuckmann)

As of 2014 it has become the default global standard for mobile communications - with over 90% market share, operating in over 219 countries and territories

2G networks developed as a replacement for first generation (1G) analog cellular networks, and the GSM standard originally described a digital, circuit-switched network optimized for full duplex voice telephony. This expanded over time to include data communications, first by circuit-switched transport, then by packet data transport via GPRS (General Packet Radio Services) and EDGE (Enhanced Data rates for GSM Evolution or EGPRS).

Subsequently, the 3GPP developed third-generation (3G) UMTS standards followed by fourth-generation (4G) LTE Advanced standards, which do not form part of the ETSI GSM standard.

We have seen evolution of communication methods from wired to wireless domain. Wireless technology evolved from 2G to 3G to currently 4G/LTE, while communication standards evolved data throughput rates increased from mere Kb/s to Mb/s and further more enhancement is possible. To match the service provider’s advancement in communication technologies handsets manufactured too has evolved in terms of hardware to support / compliment the Telecom Service Provider capability

As the subscriber base is increased from millions to billions due to increase in population as well the penetration of Telecom Service Provider is increasing another factor which became important is Quality of service, it can be perceived from both consumer as well as from service providers and both can define in their own ways

Generally consumer tend to relate their user experience in terms of Quality of service and Service providers has their own KPI's in delivering services there is always trade-off between service offered and Quality standard

## 1.2 Definition of Quality of Service (QoS)

### 1.2.1 Quality of Service (QoS)

It is the overall performance of a telephony or computer network, particularly the performance seen by the users of the network

To quantitatively measure quality of service, several related aspects of the Telecom Service Provider service are often considered, such as error rates, bit rate, throughput, transmission delay, availability, jitter, etc.

In the field of telephony, quality of service was defined by the ITU in 1994. Quality of service comprises requirements on all the aspects of a connection, such as service response time, loss, signal-to-noise ratio, crosstalk, echo, interrupts, frequency response, loudness levels, and so on. A subset of telephony QoS is grade of service (GoS) requirements, which comprises aspects of a connection relating to capacity and coverage of a Telecom Service Provider, for example guaranteed maximum blocking probability and outage probability

A network or protocol that supports QoS may agree on a traffic contract with the application software and reserve capacity in the network nodes, for example during a session establishment phase. During the session it may monitor the achieved level of performance, for example the data rate and delay, and dynamically control scheduling priorities in the network nodes. It may release the reserved capacity during a tear down phase.

A best-effort network or service does not support quality of service. An alternative to complex QoS control mechanisms is to provide high quality communication over a best-effort network by over-provisioning the capacity so that it is sufficient for the expected peak traffic load. The resulting absence of network congestion eliminates the need for QoS mechanisms

.

In packet-switched networks, quality of service is affected by various factors, which can be divided into “human” and “technical” factors. Human factors include: stability of service, availability of service, delays, user information. Technical factors include: reliability, scalability, effectiveness, maintainability, grade of service, etc.

Many things can happen to packets as they travel from origin to destination, resulting in the following problems as seen from the point of view of the sender and receiver:

### 1.2.2 Low Throughput

Due to varying load from disparate users sharing the same network resources, the bit rate (the maximum throughput) that can be provided to a certain data stream may be too low for real-time multimedia services if all data streams get the same scheduling priority.

### 1.2.3 Dropped Packets

The routers might fail to deliver (*drop*) some packets if their data loads are corrupted, or the packets arrive when the router buffers are already full. The receiving application may ask for this information to be retransmitted, possibly causing severe delays in the overall transmission.

### 1.2.4 Errors

Sometimes packets are corrupted due to bit errors caused by noise and interference, especially in wireless communications and long copper wires. The receiver has to detect this and, just as if the packet was dropped, may ask for this information to be retransmitted.

### 1.2.5 Latency

It might take a long time for each packet to reach its destination, because it gets held up in long queues, or it takes a less direct route to avoid congestion. This is different from throughput, as the delay can build up over time, even if the throughput is almost normal. In some cases, excessive latency can render an application such as VoIP or online gaming unusable.

### 1.2.6 Jitter

Packets from the source will reach the destination with different delays. A packet's delay varies with its position in the queues of the routers along the path between source and destination and this position can vary unpredictably. This variation in delay is known as jitter and can seriously affect the quality of streaming audio and/or video.

### 1.2.7 Out-Of-Order Delivery

When a collection of related packets is routed through a network, different packets may take different routes, each resulting in a different delay. The result is that the packets arrive in a different order than they were sent. This problem requires special additional protocols responsible for rearranging out-of-order packets to an isochronous state once they reach their destination. This is especially important for video and VoIP streams where quality is dramatically affected by both latency and lack of sequence.

## 1.3 Mobile QoS [Cellular QoS]

Mobile cellular service providers may offer mobile QoS ([2]S. Das)to customers just as the fixed line PSTN services providers and Internet Service Providers (ISP) may offer QoS. QoS mechanisms are always provided for circuit switched services, and are essential for non-elastic services, for example streaming multimedia.

Mobility adds complication to the QoS mechanisms, for several reasons:

A phone call or other session may be interrupted after a handover, if the new base station is overloaded. Unpredictable handovers make it impossible to give an absolute QoS guarantee during a session initiation phase.

The pricing structure is often based on per-minute or per-megabyte fee rather than flat rate, and may be different for different content services.

A crucial part of QoS in mobile communications is Grade of Service, involving outage probability (the probability that the mobile station is outside the service coverage area, or affected by co-channel interference, i.e. crosstalk), blocking probability (the probability that the required level of QoS cannot be offered) and scheduling starvation. These performance measures are affected by mechanisms such as mobility management, radio resource management, admission control, fair scheduling, channel-dependent scheduling etc.

### 1.4 Factors Affecting QoS

Many factors affect the quality of service of a mobile network. It is correct to look at QoS mainly from the customer's point of view, that is, QoS as judged by the user. There are standard metrics of QoS to the user that can be measured to rate the QoS.

#### 1.4.1 Coverage

In coverage the strength of the signal is measured using test equipment and this can be used to estimate the size of the cell.

#### 1.4.2 Accessibility

Accessibility is about determining the ability of the network to handle successful calls from mobile-to-fixed networks and from mobile-to-mobile networks

#### 1.4.3 Audio quality

The audio quality considers monitoring a successful call for a period of time for the clarity of the communication channel. All these indicators are used by the telecommunications industry to rate the quality of service of a Telecom Service Provider

### 1.5 Handover Mechanism

In cellular telecommunications, the term handover or handoff refers to the process of transferring an ongoing call or data session from one channel connected to the core network to another channel. In satellite communications it is the process of transferring satellite control responsibility from one earth station to another without loss or interruption of service. In telecommunications there may be different reasons why a handover might be conducted

#### 1.5.1 Purpose of Handover

when the phone is moving away from the area covered by one cell and entering the area covered by another cell the call is transferred to the second cell in order to avoid call termination when the phone gets outside the range of the first cell;

when the capacity for connecting new calls of a given cell is used up and an existing or new call from a phone, which is located in an area overlapped by another cell, is transferred to that cell in order to free-up some capacity in the first cell for other users, who can only be connected to that cell

When the channel used by the phone becomes interfered by another phone using the same channel in a different cell, the call is transferred to a different channel in the same cell or to a different channel in another cell in order to avoid the interference;

When the user behaviour changes, e.g. when a fast-travelling user, connected to a large, umbrella-type of cell, stops then the call may be transferred to a smaller macro cell or even to a micro cell in order to free capacity on the umbrella cell for other fast-traveling users and to reduce the potential interference to other cells or users (this works in reverse too, when a user is detected to be moving faster than a certain threshold, the call can be transferred to a larger umbrella-type of cell in order to minimize the frequency of the handovers due to this movement

In CDMA networks a handover (see further down) may be induced in order to reduce the interference to a smaller neighbouring cell due to the "near-far" effect even when the phone still has an excellent connection to its current cell

### 1.5.2 Handover Types

A hard handover is one in which the channel in the source cell is released and only then the channel in the target cell is engaged. Thus the connection to the source is broken before or 'as' the connection to the target is made for this reason such handovers are also known as break-before-make. Hard handovers are intended to be instantaneous in order to minimize the disruption to the call. A hard handover is perceived by Telecom Service Provider engineers as an event during the call. It requires the least processing by the network providing service. When the mobile is between base stations, then the mobile can switch with any of the base stations, so the base stations bounce the link with the mobile back and forth. This is called 'ping-ponging'. ([3]W. Zhao)

A soft handover is one in which the channel in the source cell is retained and used for a while in parallel with the channel in the target cell. In this case the connection to the target is established before the connection to the source is broken, hence this handover is called make-before-break. The interval, during which the two connections are used in parallel, may be brief or substantial. For this reason the soft handover is perceived by network engineers as a state of the call, rather than a brief event. Soft handovers may involve using connections to more than two cells: connections to three, four or more cells can be maintained by one phone at the same time.

When a call is in a state of soft handover, the signal of the best of all used channels can be used for the call at a given moment or all the signals can be combined to produce a clearer copy of the signal. The latter is more advantageous, and when such combining is performed both in the downlink (forward link) and the uplink (reverse link) the handover is termed as softer. Softer handovers are possible when the cells involved in the handovers have a single cell site.

### 1.5.3 Handover Techniques:-

Telecom Service Provider controlled handover.

In this type pf handover phenomenon telecom service provider direct the handset for handover even though the present cell on which device is latched is of good quality. Telecom service provider force handover in order to overcome congestion problem or sometimes due to system failure

Mobile phone assisted handover.

Here in handset keep checking the signal strength of the neighbouring cells as soon the quality of the latched cell becomes worse handset request telecom service provider for handover, once acknowledge is received from network handover is completed

# Chapter 2: Literature Review

## 2.1 TRAI Regulation

TRAI is regularly monitoring the performance of Telecom Service Providers (TSP) against the benchmarks for the various Quality of Service (QoS) parameters laid down by the Authority. TSPs submit Performance Monitoring Reports to TRAI every quarter

TRAI also undertakes audit and assessment of Quality of Service through independent agencies to verify the Quality of Service claimed. The Audit agencies conduct sample 'Drive tests' across various cities all over the country as part of audit and assessment of the TSPs' performance. The audit reports of these agencies are published on the website of TRAI. ([4]"Reduced Call Drop Rate in a 4G Network using Vertical Handoff Algorithm")

In view of complaints on call drops and other Telecom Service Provider issues, on behalf of TRAI, an independent Drive Test (IDT) was conducted and uploaded in the website, on ([5]"Home: Telecom Regulatory Authority of India", n.d.)

23rd & 24th June 2015 covering various locations in South and Central Mumbai & 9th to 11th July 2015 covering various locations in South Delhi, Central Delhi and West Delhi.

Subsequently another independent drive test was conducted in Delhi on the same routes on 27th & 28th of September 2015. In addition to Delhi and Mumbai

## 2.2 TRAI Drive Test Schedule

i. Kolkata: 15th and 16th September 2015.

ii. Pune: 14th and 15th September 2015.

iii. Surat: 16th and 17th September 2015.

iv. Bhubaneswar: 18th and 19th September 2015.

During December 15 to January 16 drive tests were repeated in these six cities and in addition drive tests were carried out in Indore also. The tests were carried out on following dates.

i. Delhi -21st January to 25th January, 2016

ii. Mumbai-5th January to 8th January, 2016

iii. Kolkata-21st December to 23rd December, 2015

iv. Pune-28th December to 30th December, 2015

v. Surat- 21$^{st}$ December to 23$^{rd}$ December, 2015

vi. Bhubaneswar 28$^{st}$ December to 30$^{th}$ December, 2015

vii. Indore-4$^{th}$ January to 7$^{th}$ January, 2016

In all the cities were Drive tests were carried out earlier, the same route was followed during the latest drive.(i.e. around 300kms) For Delhi and Mumbai, the route length was increased to 600 Km after taking inputs from the TSPs about the additional route. In other cities also, the route has been increased wherever possible

A team from the TRAI HQ was present for these Drive tests during these days. During the current drive tests 2G networks as well as 3G networks were tested while in earlier tests only 2G Networks were covered.

### 2.3 TRAI Audit Points

The test results obtained from these drive tests were conducted to assess the Telecom Service Provider condition more specifically in terms of:-

#### 2.3.1 Radio Frequency (RF) Coverage

Service provider's coverage in a wide area is measured and tested to check the quality, generally more would be coverage more will be satisfaction level of the customers and it is directly proportional to the business to the service providers

#### 2.3.2 Rx Quality

Rx quality depicts the quality of voice on a scale of 0 to 7, 0 stands to best quality and 7 stands worst quality. Quality also depends on the handsets hardware as well and the mechanical designs

#### 2.3.3 Call Setup Success Rate

It is defined as the pass rate of the call originated which are successful in the in first attempt only higher the success rate depicts good coverage as well as congestion free Telecom Service Provider

### 2.3.4 Call Drop Rate

Call drop can be defined as the ration of number of active call dropped to actual number of calls made, higher the call drop means lesser satisfaction to customers

These days call drop is highlighted as top most KPI for the service providers from government regularities bodies. TRAI is conducting independent drive in many cities in India for all the operators present in particular telecom circle and officially publishing results online and further planning to impose fine on service providers if the basic QoS is not maintained

### 2.3.5 Voice Quality

Voice quality can be measured observed in various ways for example loudness, Echo while talking, mute observed in an active call, Color of voice

Voice quality is considered as the most important characteristics of an active call the louder and clear voice better would be communication. Voice quality degrades as the network strength varies at times it is observed in low signal area voice quality degrades significantly and eventually call drop is observed is low or no signal are is present for long time

### 2.3.6 Blocked Call

Blocked call is the basic operational feature of BTS which allocate channel for voice call. If block rate is higher it implies the network has poor radio frequency planning and various network optimization techniques are not used properly. Blocked calls can be reduced by frequency reuse concept as well as planning GSM cells more efficiently

### 2.3.7 Carrier to Interference Ratio

Refers to ratio of Signal to Noise, even though is signal is very string but noise is also present in considerable amount then final quality of the voice call will degrade

### 2.4 Problem Statement: TRAI Benchmark

Most critical issue which a customer can face and easily observe is Call Drop while talking to somebody in a stationary or driving condition. Frequent call drop will increase dis-satisfaction with the customer for a particular telecom service provider and customer probably will switch to new service provider. I will be checking different call drop failure reason and would categorize in two categories i.e. Service Provider issue and the Handset side issue's

Primary approach would be check all the service provider related problem and share with them for appropriate actions to reduce the call drop rate, Handset side issues are not important as generally there are less handset issue's as most of the issue happens due protocol related failure while the handset is handshaking with the service provider

Based upon the drive by the independent testing body, TRAI has already tested in many cities in India and found most of the cities have bad QoS. Further TRAI has laid down the QoS benchmarks for call drop rate to be less than 2%

**Retainability Summary and Ranking**

| Operator | Total Call Established | Total Call Drop | CCSR | CDR | Ranking |
|---|---|---|---|---|---|
| Airtel 2G | 996 | 14 | 98.59% | 1.41% | 2 |
| Aircel 2G | 951 | 25 | 97.37% | 2.63% | 6 |
| Idea 2G | 1018 | 21 | 97.94% | 2.06% | 5 |
| Vodafone 2G | 1008 | 39 | 96.13% | 3.87% | 9 |
| RCOM 2G | 979 | 29 | 97.04% | 2.96% | 7 |
| MTNL 2G | 906 | 86 | 90.51% | 9.49% | 14 |
| Airtel 3G | 887 | 14 | 98.42% | 1.58% | 3 |
| Idea 3G | 828 | 14 | 98.31% | 1.69% | 4 |
| Vodafone 3G | 806 | 11 | 98.64% | 1.36% | 1 |
| RCOM 3G | 793 | 36 | 95.46% | 4.54% | 11 |
| MTNL 3G | 665 | 46 | 93.08% | 6.92% | 13 |
| Reliance CDMA | 1159 | 47 | 95.94% | 4.06% | 10 |
| Tata CDMA | 1136 | 57 | 94.98% | 5.02% | 12 |
| MTS CDMA | 1221 | 40 | 96.72% | 3.28% | 8 |

**CCSR:** Call completion Success Rate
**CDR:** Call Drop Rate

**Figure 1 : Independent drive test report for TRAI for Delhi Telecom circle**

As per the data shown in Figure 1, it is not defined out of total call drop rate recorded how much contribution from service provider side and how much from device side

In order to verify and prove that most of the contribution for call drop is from service provider side i will study various call drop failure and try to categorize failure from network side and hence will propose service providers to improve their service with exact failure reasons with analysis through logs captured

**Justification**: Based upon the TRAI feedback about the call drop failure I will segregate the failure in 2 categories and will further interpret that most of the failure are from service provider side and compared to device side

## 2.5 Call Drop Importance

Call drop percentage or the count is significant in terms of selecting best service provider for a given telecom circle, customer can decide and choose the relevant operator based upon the call drop test results. ([6]A. Wilfred and A. Theophilus)

Service provider can also by considering the call drop can plan to improve their infrastructure, can plan to add more BTS to meet the customer demand and so on Service provider can focus more upon the better Radio Frequency Planning to optimize the existing resources as well to use other parameters such as frequency re-use more efficiently

Indian government is planning to impose penalty on the telecom service provider for call drop, as per the latest news telecom service provider has to pay for each call drop to the user

## 2.6 Available Telecom Service Provider in India

| Rank | Operator's Name | Subscribers in million | Market Share |
|---|---|---|---|
| 1 | Airtel India | 248.6 | 32.35% |
| 2 | Vodafone India | 196.7 | 25.59% |
| 3 | Idea Cellular | 174.6 | 22.72% |
| 4 | Reliance Communications | 106.81 | 11.21% |
| 5 | Aircel | 86.06 | 8.47% |
| 6 | BSNL | 85.29 | 8.19% |
| 7 | Tata Docomo | 60.89 | 6.28% |
| 8 | Telenor India | 5.16 | 4.91% |
| 9 | MTS India | 8.13 | 0.89% |
| 10 | MTNL | 3.6 | 0.36% |

**Table 1 : Available Telecom Service Provider in INDIA**

Table 1 shows various service providers present in different telecom circle, In India we have 22 Telecom circles

All the above mentioned telecom service provider are not available in all the telecom circle telecom service provider has roaming contract with each other to provide seamless connectivity to the customers through the facility of Roaming

## Chapter 3: Proposed Work

There are 3 possible ways for call drop improvement:

- Optimization in handset software by considering 3 major categories of Telecom Service Provider Issues:-
  - Radio Link Failure
  - Network Released call
  - Handover Failures
- Optimization of Hardware, To be taken care by HW R&D team for future models
- Operator Collaboration:

Joint test with operator, Sharing of Telecom Service Provider issues Technical Report for Call Drops occurred due to Telecom Service Provider Issues. Operator to check network logs and suggest for Device side improvement

I have considered call drop parameter as one of the indicator to measure the QoS. Call drop is an crucial aspect for a customer many times the reason are unknown to customers except for festival seasons when there is too much load on the service provider to provide service to all

Purpose of long call drop test is to check the call drop state that occurs in soft handover, hard handover condition etc. many kind of network environment and modification about the case in which issue in the terminal

I have tried to optimize one of the test parameters Drive test in order to measure the Telecom Service Provider capabilities in terms of providing the good services to the customer's

While on driving test continuous logs are captured while call is ongoing following traces are captured from the Telecom Service Provider side

- Communication protocol between network and the handsets
- Measurement of the RSSI / Received Signal Strength of all the cells present at one particular area
- Handover mechanism monitoring ( hard handover / soft handover )
- Handsets behaviour is also monitored once No Service area is observed
- Time to latch to network is considered

- Real time response of test phones vs competition phone is compared to help to conclude which side has the problem device or the Network

### 3.1 Identify Drive Test Route

Drive route identification is the crucial step where in only best route i.e. good signal area need to be considered for the testing so that we can avoid the case where is due to poor connectivity QoS is not maintained from service provider's

Service providers can deny the test results that due to congestion of low signal strength call are dropped also further service providers can quote examples of limited spectrum availability

Step 1:- Prepare data table: As per TRAI standard Signal strength should be above -85 dBm [Download network cell info apk from Android market]

| Test Iteration | Device Information | Result : Average Cell strength measurement on the drive route |
|---|---|---|
| Iteration 1 | Test Device 1 | |
| Iteration 2 | Test Device 1 | |
| Iteration 3 | Test Device 1 | |
| Iteration 4 | Test Device 1 | |
| Iteration 5 | Test Device 1 | |
| Iteration 1 | Test Device 2 | |
| Iteration 2 | Test Device 2 | |
| Iteration 3 | Test Device 2 | |
| Iteration 4 | Test Device 2 | |
| Iteration 5 | Test Device 2 | |

**Table 2 : Cell Strength Measurement 1st Table**

Step 2: Start drive test with all the samples together and follow test procedure for measuring the cell power strength with logging on by android application “Network Cell info Lite”

Step 3: Follow different route each day and record the data, record all the drive test route D1, D2, D3 and so on with clearly indicating the average cell power observed on the device side for the network cells

| S. No | Drive Test route | Average Cell Power recorded based upon the no of cells passed through |
|---|---|---|
| 1 | D1 | Average dB Range |
| 2 | D2 | Average dB Range |
| 3 | D3 | Average dB Range |
| 4 | D4 | Average dB Range |
| 5 | D5 | Average dB Range |
| 6 | D6 | Average dB Range |
| 7 | D7 | Average dB Range |
| 8 | D8 | Average dB Range |
| 9 | D9 | Average dB Range |
| 10 | D10 | Average dB Range |

**Table 3 : Cell Strength Measurement 2$^{nd}$ Table**

Various drive route are evaluated so that best route is chosen for considering failure and to avoid cases which are due bad network conditions

Drive route captured for reference purpose

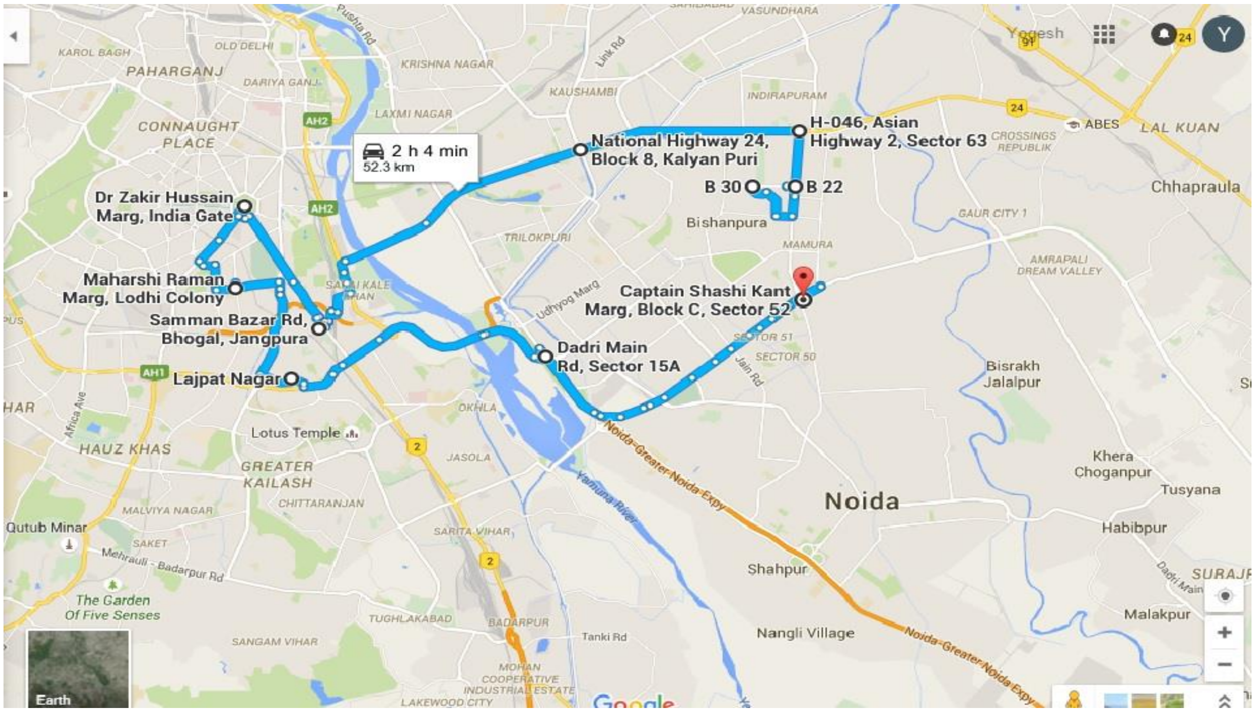


**Figure 2 : Drive Route: D1**

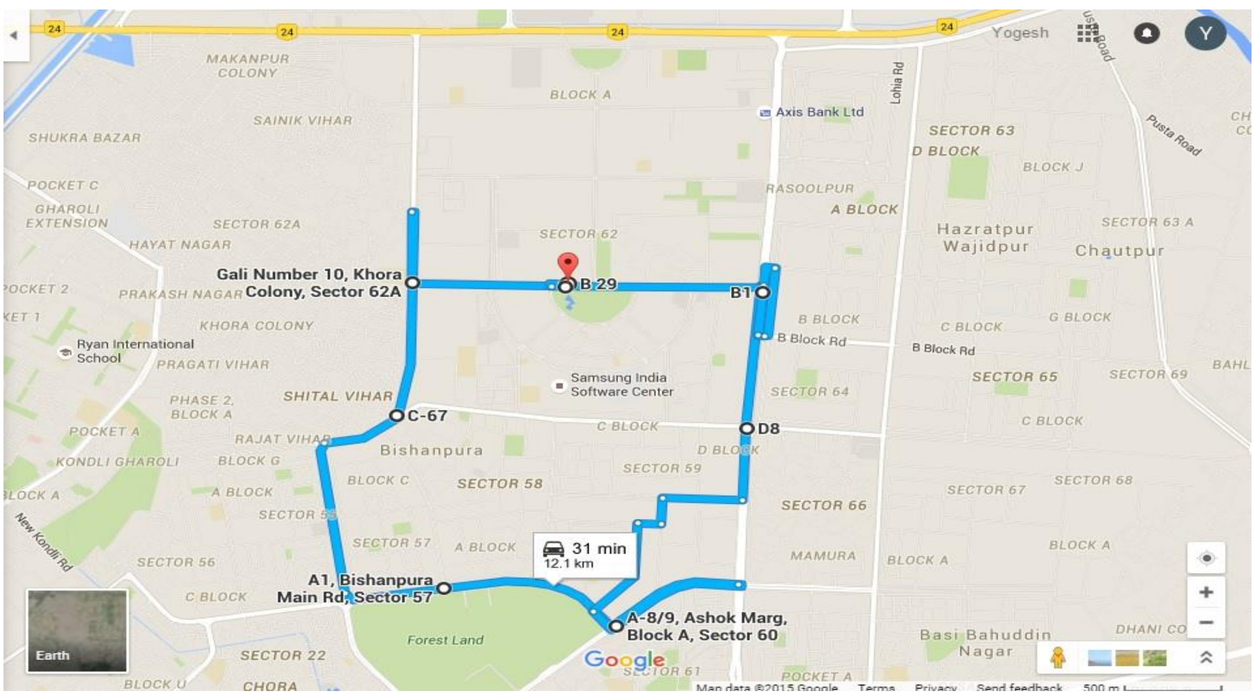


**Figure 3: Drive Route: D2**

Step 4: Best route identified based upon the best average signal strength while driving and by monitoring in office buses through Android application

### 3.2 Service Provider Selection

Airtel and Vodafone are tested initially in Delhi & NCR, Airtel was chosen as due maximum subscriber base and good coverage area for all the communication standards 2G, 3G, and 4G

### 3.3 Test & Simulation Application

Download "Network Cell Info lite "application from android market and run to check the network strength in real time


**Figure 4 : Network Cell Info lite (Simulation Application)**

### 3.4 Testing Methodology

Step1: Run Dump state logs in the device, test as well reference devices

Step2: Set debug level as mid so that maximum can be captured in device side

Step3: Make long MO call while driving, if call drop occurs make another call

Step4: Save all the logs for each call drop

All the above steps can be done automatically by special applications as well

Step5: Extract logs and analyse the same

Step6: Filter symptom in 2 categories Device side & Network Side drops

Note: Need to discard call drop if call drop occur in both the test and reference device at the same time

### 3.5 Terms and Abbreviation

| Terms | Description |
|---|---|
| 2G, 3G, 4G | Second, Third, Fourth Generation |
| SCell | Serving cell |
| NCell | Neighbour cell |
| ACI | Adjacent channel interface |
| ARFCN | Absolute radio frequency channel number |
| RxLevel | Received signal strength |
| RxQual | Received signal quality |
| SI | System information |
| HO, CDMA | Handover, Code Division Multiple Access |
| UE | User equipment |
| NW, HW, SW | Network, Hardware, Software |
| RSSI | Received Signal Strength Indicator |

| | |
|---|---|
| dB | Decibel |
| TRAI | Telecom Regularity Authority of India |
| MO, MT | Mobile Originated, Mobile Terminated |
| RLF | Radio Link Failure |
| BTS | Base Trans receiver System |
| RRC | Radio Resource Connection |
| UE | User Equipment |
| SABM | Set Asynchronous Balance Mode |
| LTE | Long Term Evolution |
| FCCH | Frequency Correction Channel |
| T3124 | Timer protocols for handsets |
| CM Service Request | Connection Management Service |
| RLT | Radio Link Timeout |
| IVR | Interactive Voice Response |
| RAT | Radio Access Technology |
| BCCH | Broadcast Control Channel |

**Table 4 : Terms and Abbreviation used in Test Methodologies**

**3.6 Identification failure cause & Justification for focusing service provider optimization**

| S. No | Handset Manufacturer | Quantity | Model Name | Call Processor |
|---|---|---|---|---|
| 1 | Samsung | 2 | Galaxy S5 / I9500 | Qualcomm Based |
| 2 | Apple | 2 | IPhone 6+ | Apple Proprietary |

| S. No | Details | Duration |
|---|---|---|
| 1 | Test Duration | Feb ~ April 2016 |
| 2 | Total number of calls made in Samsung Device | 2000 |
| 3 | Total number of calls made in Apple Device | 2000 |
| 4 | Total call dropped in Samsung device | 82 [ 4.1% ] |

| S. No | Total call drops breakup in terms of network side issue's | | |
|---|---|---|---|
| | Total Call drops | 82 | % |
| 1 | BTS Timing Advance | 2 | 2.4 |
| 2 | Handset capability | 4 | 4.8 |
| 3 | Invalid Handover | 2 | 2.4 |
| 4 | Radio Link Failure | 35 | 42.68 |
| 5 | Channel Release | 10 | 12.19 |
| 6 | High Interference | 15 | 18.29 |
| 7 | Network Initiated | 10 | 12.19 |
| 8 | Device Issue | 4 | 4.8 |

**Table 5 : Initial Simulation for Identifying Call Drop Failure Status**

Summary: From the above data from table 5 it is clearly visible that out of the total failure more than 95% failure is from the service provider side, device side contribution is only 5%.

Area of concern / focus is Service provider optimizations because improvement from device side would not contribute in the call drop rate improvement significantly

Graphical presentation of call drop failure cause and category

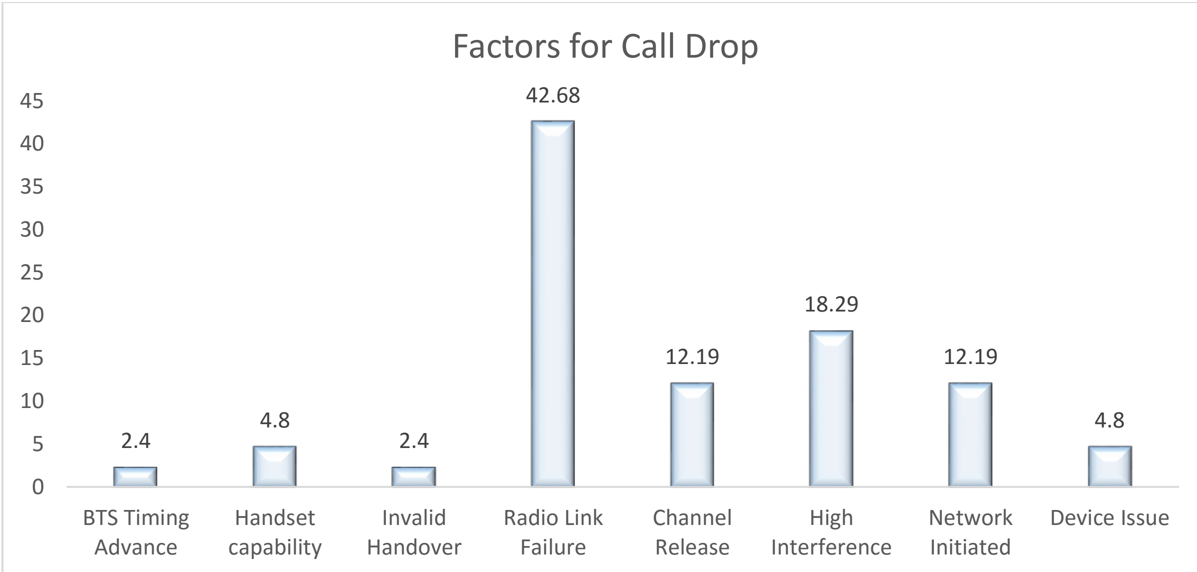


**Figure 5 : Initial Simulation for Identifying Call Drop Failure Status**

Based upon data shown in Table 5 & Figure 5 optimization from service provider is required to improve call drop rate as handset side contribution is only 4.8 %

Area to focus from service provider side are Radio Link failure, High Interference, Network initiated, channel release command, Network initiated command for channel release, Invalid Handover command to the handsets ([7]R. van Nobelen), ([8]V. Manelis)

## Chapter 4: Call Drop Analysis

After rigorously testing and collection of logs and data majorly call drop can be divided into two categories

- Call drop initiated from Service Provider side
- Call drop initiated from Handset side

I will explain in detail for the failure due to network side only

Major categories in which call drop failure can be categorized corresponding to service provider failure are listed below:-

- Call drop due to Handover operation failure
  Network is not responding to handover command initiated by handset

- Call drop due to channel release by channel
  Network sent command to handset to release channel

- Call drop due to Radio Link failure [ RLF ] ([7]R. van Nobelen)
  Network radio link failed

- Call drop due to Radio Resource Connection Release ([6]A. Wilfred and A. Theophilus)
  Network sent command for connection release to handset

- Call drop due to Network initiated disconnection command
  Some kind of network issue or mechanism

- Call drop due to No handover command sent to device from network side
  Network is not responding to handset for handover related handshake

- Call drop due to Invalid handover command from network side
  Network sending wrong command ([3]W. Zhao)

- Call drop due to network inability to handle handset capability broadcast message
  Network capability issue

- Call drop due to BTS timing advance
  Network side configuration issues

## 4.1 Standard Call Procedure

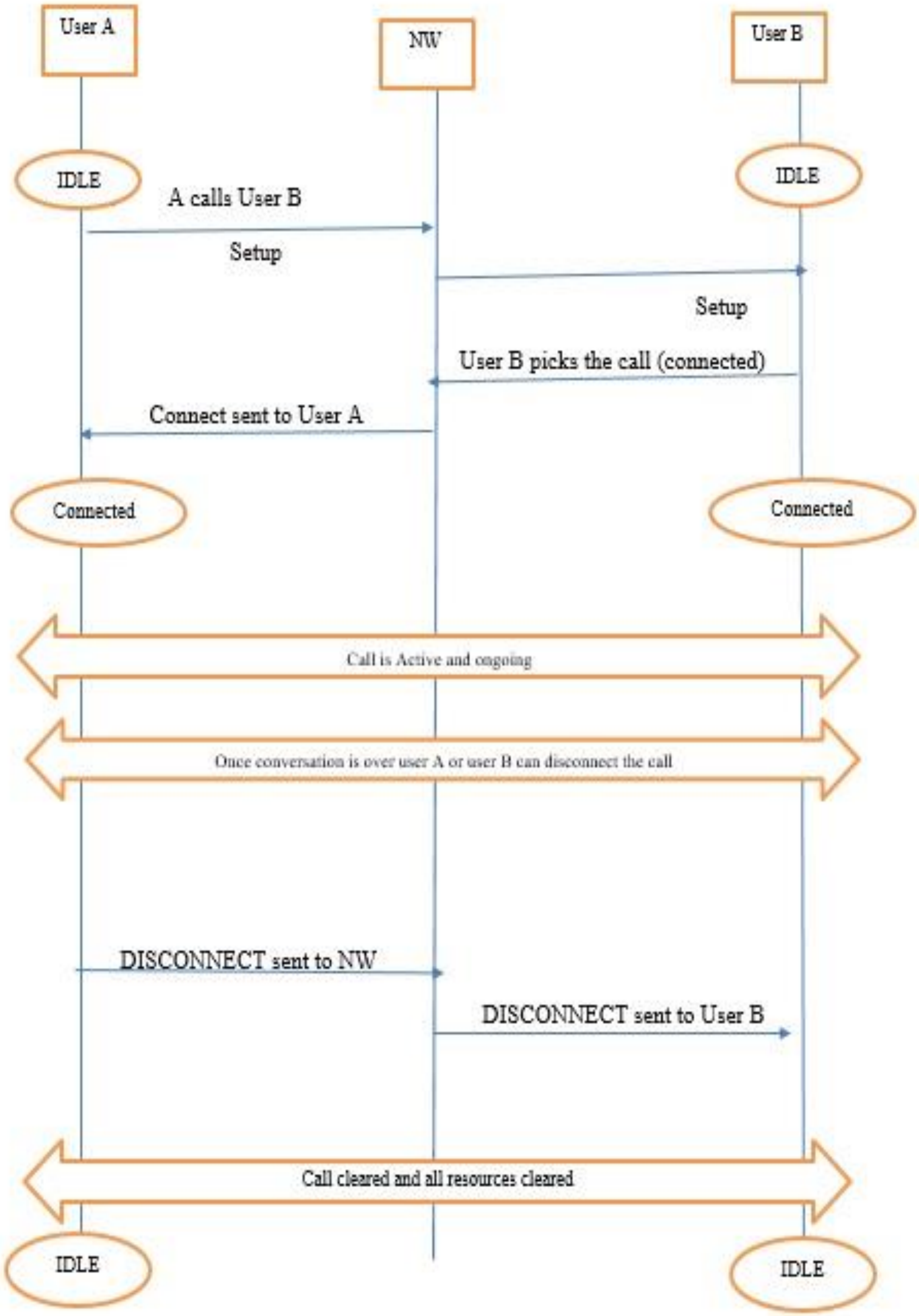


**Figure 6 : Explains basic mobile call origination and termination protocol flow**

### 4.1.1 Case 1: Handover Failure Scenario

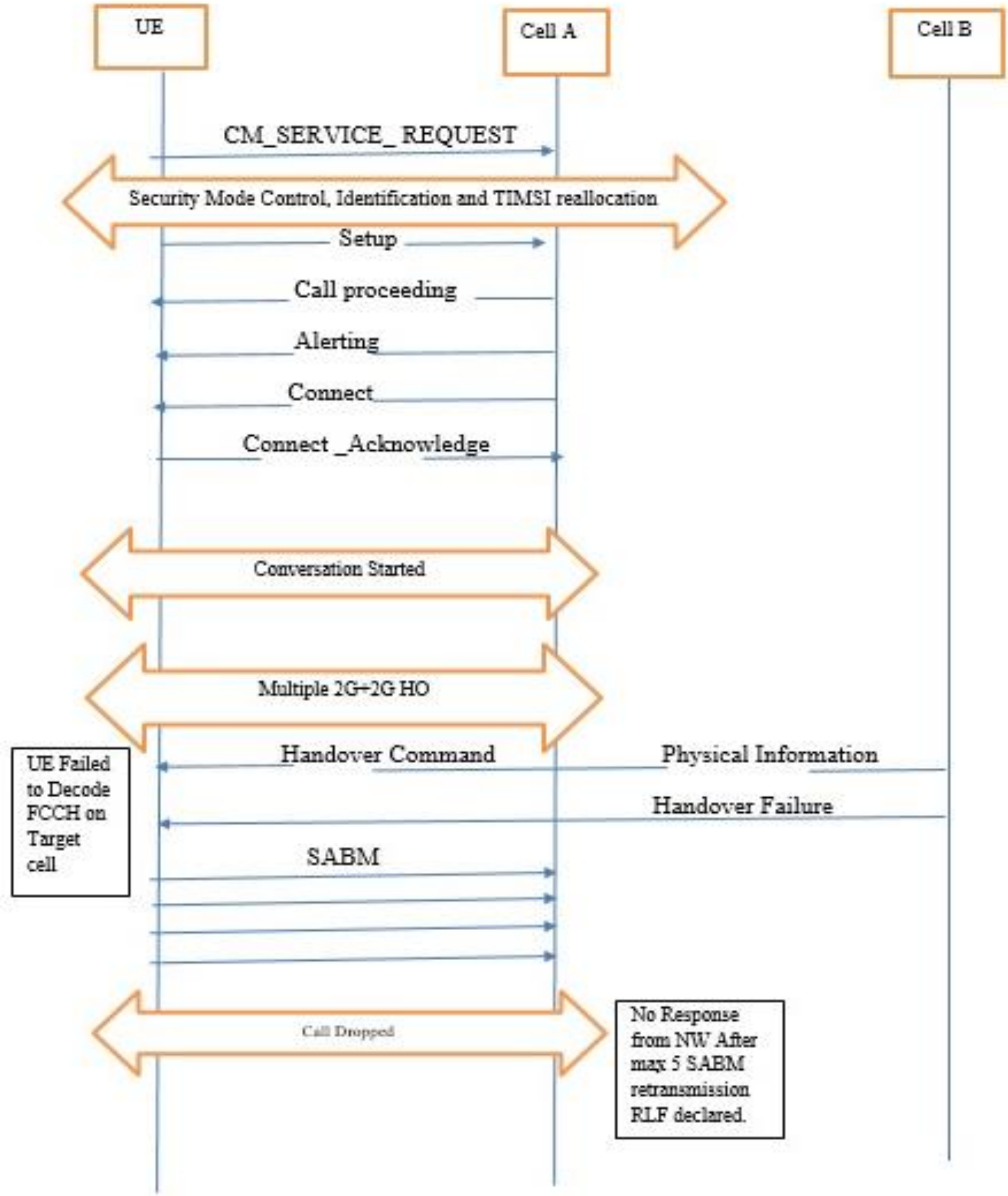


**Figure 7 : Explains basic mobile call drop due to handover failure from network side**

### 4.1.2 Case 2: Channel Release by Network

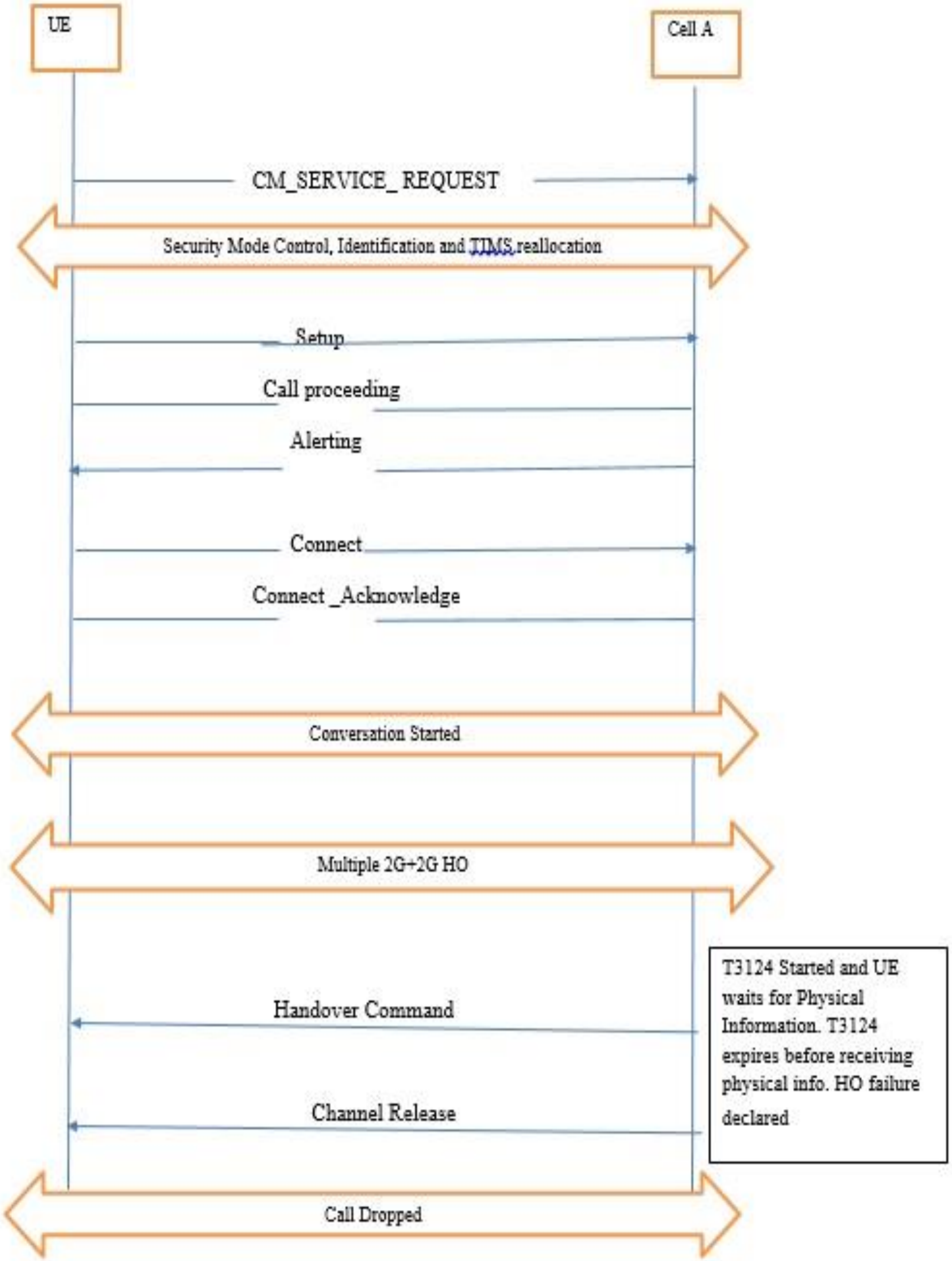


**Figure 8 : Explains basic mobile call drop due to channel release command from network**

### 4.1.3 Case 3: Radio Link Failure

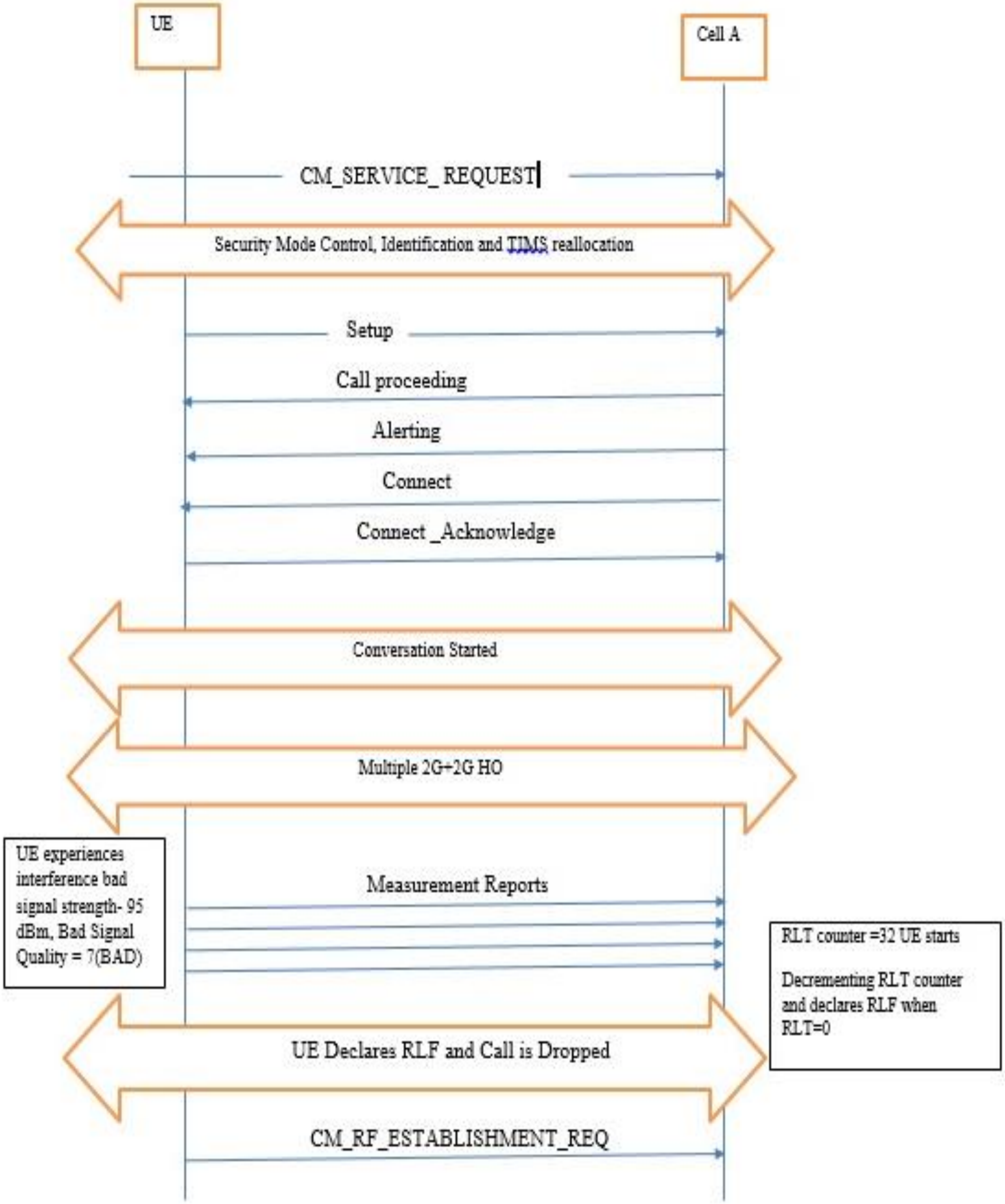


**Figure 9 : Explains basic mobile call drop due to Radio Link Failure**

### 4.1.4 Case 4: RRC Connection Release

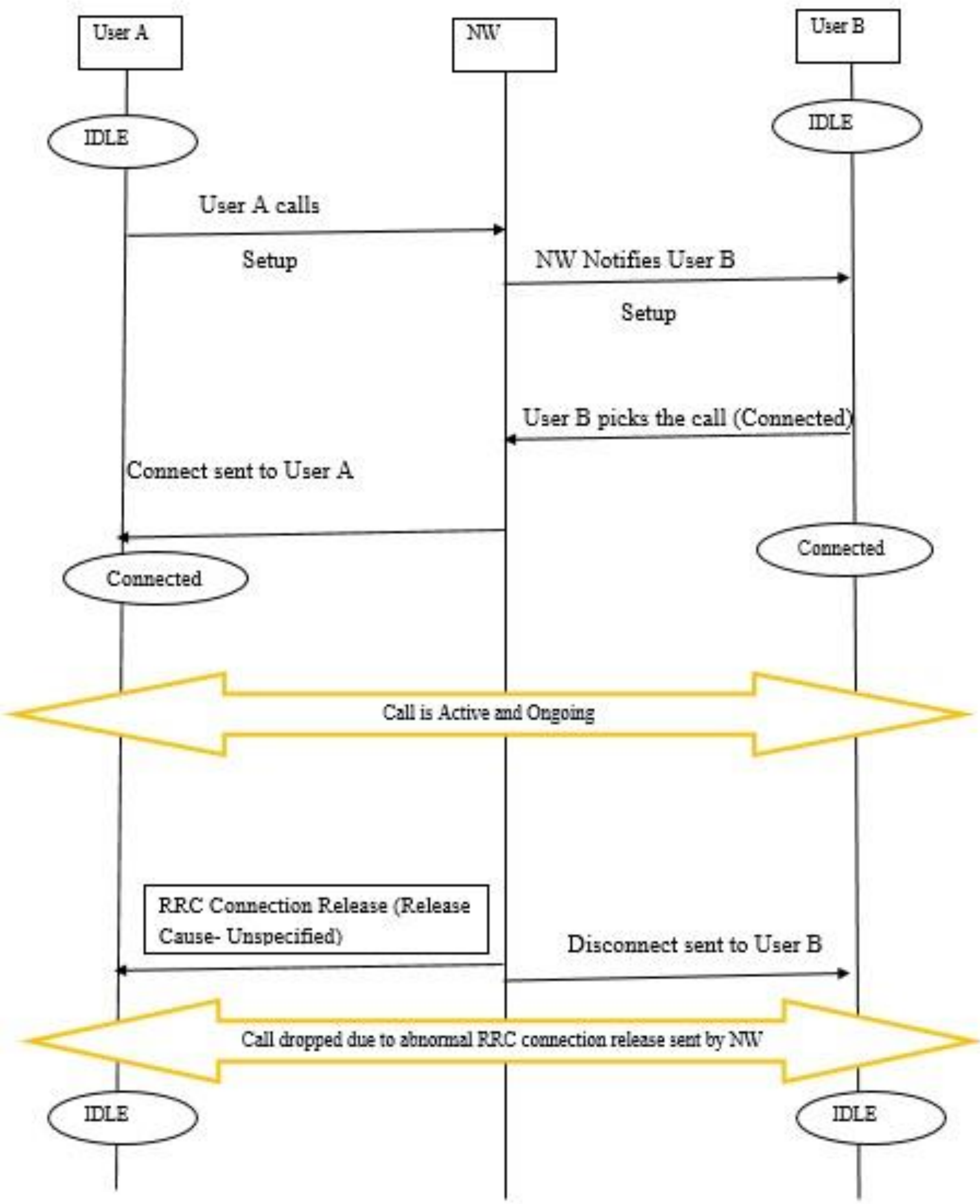


**Figure 10 : Explains basic mobile call drop due to RRC Release command from network**

### 4.1.5 Case 5: Disconnect Instruction from Network Side

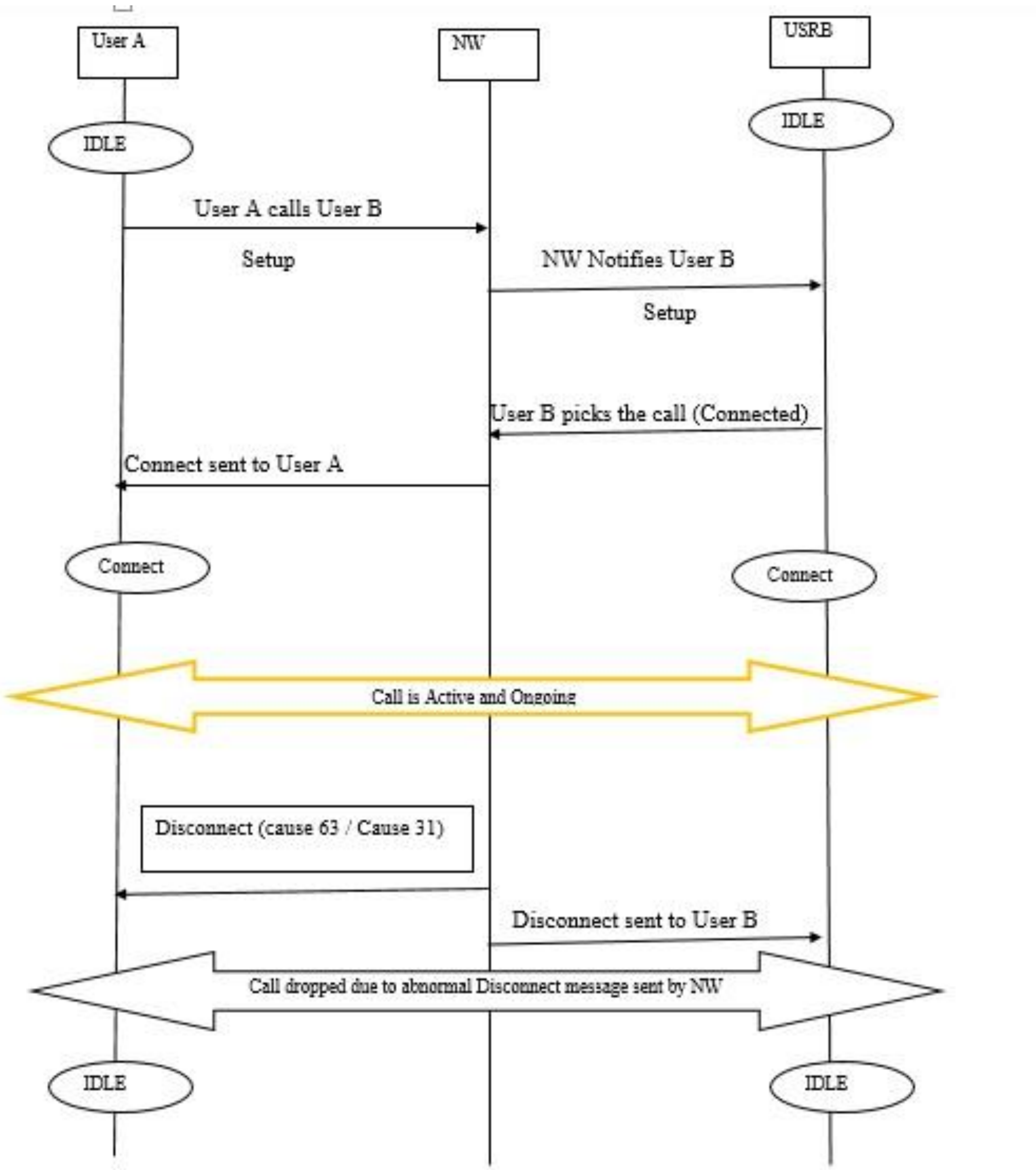


**Figure 11 : Explains basic mobile call drop due to network disconnect instruction from network**

### 4.1.6 Case 6: No Handover Command Received

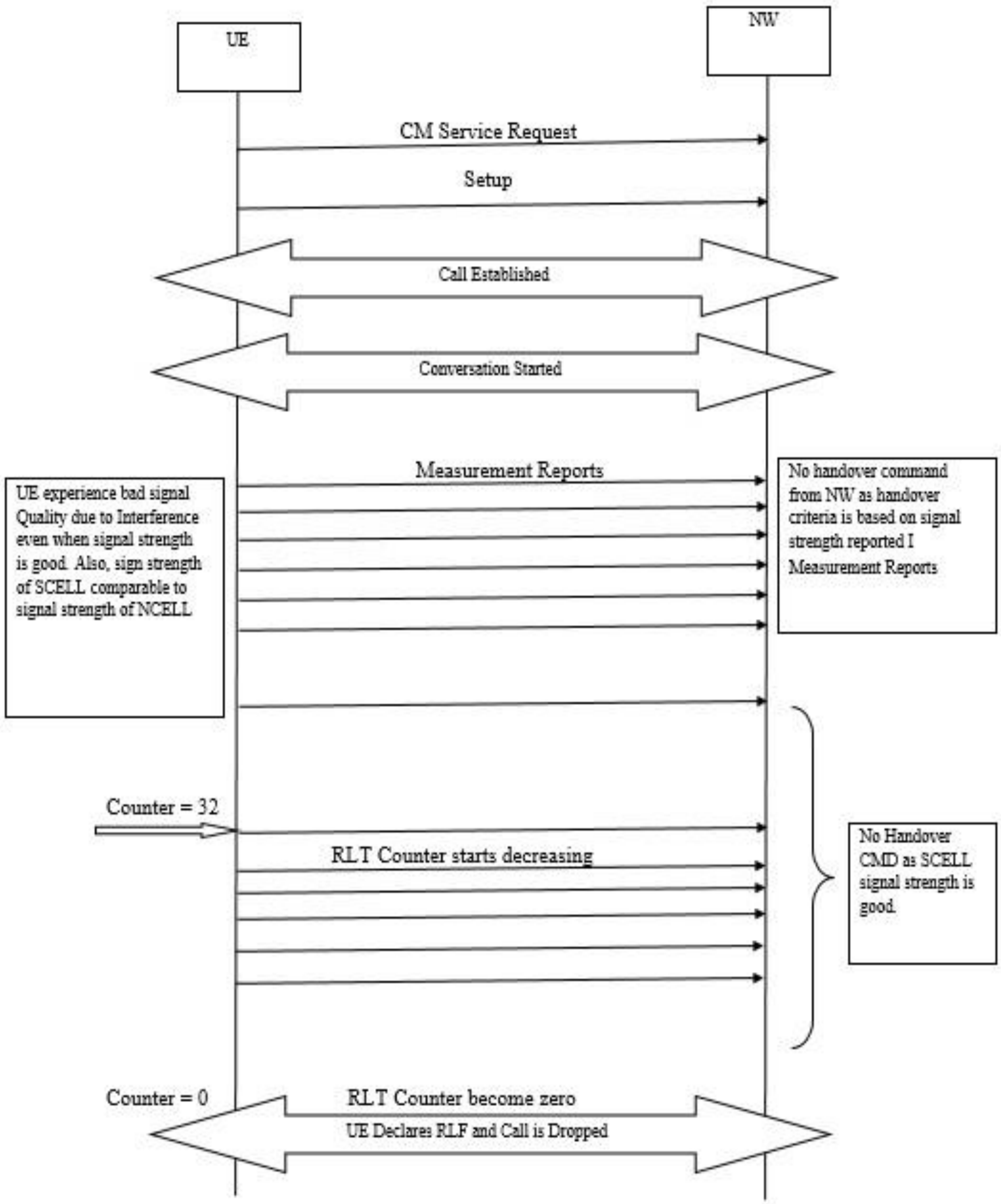


**Figure 12 : Explains basic mobile call drop due to No handover command from network**

#### 4.1.7 Case 7: Invalid Handover Command

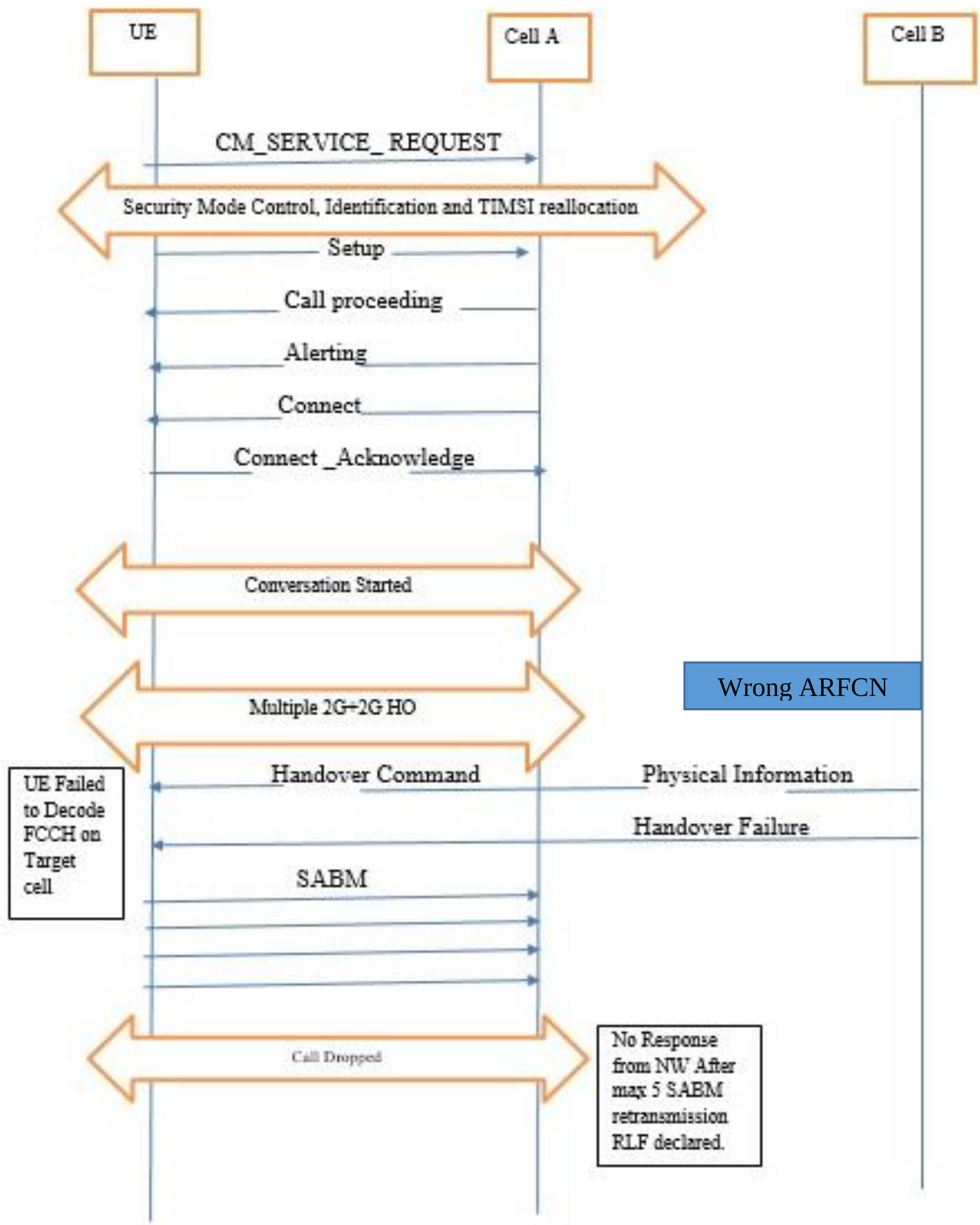


**Figure 13 : Explains basic mobile call drop due to Invalid handover command from network**

#### 4.1.8 Case 8: Network Inability to Handle Handset Broadcast Message

In this specific case while in active ongoing call network requested to device to broadcast it capability of supporting different types of network supported by the device 2G, 3G, 4G, Carrier Aggregation types supported, Band support ([9]J. Acharya)

All the above information is crucial from network point for optimizing the service provider network capabilities by moving devices to different bands and technology as and when required by the service provider

In this specific case after network has requested the device capability message to the device, on receiving the response the network took long time to read and respond to broadcasted message by the handsets, due to delay in response the call was dropped from the network side as the test device was in driving condition. Later when thoroughly checked it was concluded from service provider side they need to upgrade their infrastructure and a new firmware is required to be upgraded at the BTS side ([10]A. Perez)

As per the logs, once the information is received from the device in 64 Bit format, there is delay in processing of information at network side, due to this delay in processing active call is dropped as handset is awaiting network response for particular time interval

#### 4.1.9 Case 9: BTS Timing Advance Error

In this specific case while in active call while driving normal handover are expected for this specific case there was not proper time synchronization between service provider and the handset which is experiencing handover while moving

As soon as the time miss match is detected network gives command to release the active channel on which call is ongoing. Call is dropped from the network side as a security policy and for new call time would be in sync, Time synchronization between handset and device is very important and crucial, Mismatch occurred due to test device was in driving condition and there was mismatch between the latched BTS and the new handed over BTS

# Chapter 5: Simulation Setup & Result Analysis

Simulation is done by capturing the logs in the handset while driving and by comparing with the competitor at the same time. If there is abnormal behaviour in both the handset then that particular case were discarded. Only those logs are considered wherein only problem is reproduced in test device only. Basic Log capturing tool is used, Regular calls of 10 minutes are made for the entire durations

### 5.1.1 Logs Analysis to Problem Referred in 4.1.1

Case 1: Call Drop Due To Handover Failure

Purpose: To inform that call dropped on the device because it did not receive any Physical Information from the N/W after the Handover command was initiated

Problem Scenario: Make Call on IVR.

*Basic information:*

Cell Info: GSM ARFCN: 62, RAT: GSM, Cell Id = 44051

PLMN = {404 10}, Lac = 245, ARFCN = 62, Bsic = 49

Analysis result: Handover Failure as Physical information is not received.

Call Failure Cause: HO failure.

Call DROP/SETUP Issue: DROP

Failure Category: Call drop due to HO failure.

*Analysis Results:*

Call dropped due to failure in G2G handover. A handover failure was reported from DUT as no Physical information was received from the N/W after the Handover command was initiated.

T3124 timer started after Handover command from N/W and expired after 30ms as no Physical Information was received from N/W.

Due to which call drop occurred. It must be a NW issue.

12:54:17.308 GSM DSDS RR Signalling Message -- Handover Command

bcch_arfcn_low = 52 (0x34)    // Handover was directed to ARFCN 52

12:54:17.336    Starting T3124 (320) TCH

12:54:17.656    T3124 expired

12:54:17.677 GSM DSDS RR Signalling Message -- Handover Failure rr_cause_val = 3 (0x3) //Abnormal release, since no Physical Information is received from N/W T3124 timer expires and Handover failed

*Conclusion:*

*Call was dropped on the device because device did not receive Physical Information message from the N/W after the Handover command which resulted in Handover failure.*

### 5.1.2 Logs Analysis to Problem Referred in 4.1.2

Case 2: Call Drop Due To Channel Release

Purpose: To inform that voice call dropped on the device because it has received Radio Bearer Release with RB identity: 5, 6 and 7 from the network

Problem Scenario: Make Call on IVR.

*Basic information:*

RAT: 3G, Active Set: ARFCN: 10833 PSC: 191 EcNo: -8 Rscp: -60

*Analysis Results:*

// device is in good signal condition and has performed removal of active set cell successfully.

15:08:07.238 RRC active Set Update

Removal: PSC: 228

15:08:07.261 RRC active Set Update Complete

Active Set: ARFCN: 10833 PSC: 191 EcNo: -8 Rscp: -60

// Device has received Radio Bearer Release message from the network to release RB identity: 5, 6 and 7.

15:08:07.664 RRC radio Bearer Release

RB-InformationReleaseList: 3 items: RB-Identity: 5, 6, 7

15:08:08.171 RRC radio Bearer Release Complete

*Conclusion:*

*Call was dropped on the device because it received Radio bearer Release from the network side to release radio bearers having RB Identity: 5, 6 and 7.*

### 5.1.3 Logs Analysis to Problem Referred in 4.1.3

Case 3: Call Drop Due To Radio Link Failure

Purpose: To show call are drops due to poor radio conditions of service provider

Problem Scenario:

Voice call established, and perform drive test.

*Basic Information:*

ARFCN: 58 Cell CI: 0xf9ef (63983), Location Area Code (LAC): 0x0150 (336)

*Analysis Results:*

Network sent handover command to a 2G ARFCN that wasn't reported by MS in earlier measurement reports.

15:36:19.968 ST1 SCell: 51 Org FullRxL: 22 SubRxL: 23 FullRxQ: 4 SubRxQ: 0 RxLev_val: 22 SoftSumFull 939 SoftSumSub 994

15:36:19.969 ST1 Index (5) Freq (58) Bsic (27) RxLev (50) ValidBsic (1)

15:36:19.969 ST1 Index (2) Freq (55) Bsic (1e) RxLev (44) ValidBsic (1)

15:36:19.969 ST1 Index (0) Freq (51) Bsic (4) RxLev (34) ValidBsic (1)

15:36:19.969 ST1 Index (7) Freq (60) Bsic (39) RxLev (16) ValidBsic (1)

15:36:19.969 ST1 Remaining 2G cells: 4

15:36:19.969 ST1 (NbMeas=4)

15:36:20.427 ST1 HO: ARFCN (58) NCC (4) BCC (7) BSIC (27)

15:36:20.428 ST1 Arfcn = 560

15:36:20.428 ST1 Arfcn = 617

15:36:20.428 ST1 Arfcn = 615

15:36:20.428 ST1 Arfcn = 691

15:36:20.872 ST1 SCell: 58 Org FullRxL: 34 SubRxL: 22 FullRxQ: 2 SubRxQ: 4 RxLev_val: 33 SoftSumFull 983 SoftSumSub 902

Rxqual became bad as SD and CIRatio became low. Radio link failure was observed on device and call was dropped.

15:37:55.026 ST1 SCell: 58 Org FullRxL: 18 SubRxL: 16 FullRxQ: 7 SubRxQ: 7 RxLev_val: 0 SoftSumFull 207 SoftSumSub 204

15:37:55.026 ST1 SCell: 58 Org FullRxL: 18 SubRxL: 16 FullRxQ: 7 SubRxQ: 7 RxLev_val: 0 SoftSumFull 207 SoftSumSub 204

15:37:55.502 ST1 SCell: 58 Org FullRxL: 18 SubRxL: 17 FullRxQ: 7 SubRxQ: 7 RxLev_val: 0 SoftSumFull 217 SoftSumSub 99

*Conclusion:*

*Call drop happened due to Radio Link Failure in ARFCN 58.*

Test seems to be conducted in interference area as NCell was not detected much even with high RXLEVs. The call drop happened by Radio Link Failure when the Serving Cell RXLEV for TCH was around -95 ~ -100dBm.

There was no abnormal handset behaviour and call drop happened by bad signal condition.

### 5.1.4 Logs Analysis to Problem Referred in 4.1.4

Case 4: Call Drop Due To Rrc Connection Release

Purpose: To check and analyse call drop failure due to no response for Radio Bearer re configuration from the network

Problem Scenario:

Make Call on IVR.

*Basic information:*

RAT: 3G, Cell Info: Active Set: ARFCN: 10833 PSC: 363 EcNo: -9 Rscp: -65

*Analysis Results:*

// device was received Radio bearer reconfiguration for SRNC relocation.

10:38:34.418 RRC DL.DCCH radioBearerReconfiguration

new-U-RNTI

srnc-Identity: 0030

s-RNTI: 02a410

10:38:34.426 CUPHY_DEDICATED_MODE_CONFIG_REQ (49419)

dlUarfcn: 10833

RefRlPrimaryScrCode: 363

10:38:34.566 measurementReport

trafficVolumeEventIdentity: e4a

10:38:34.576 CUPHY_DEDICATED_MODE_CONFIG_CNF (49419)

// device has sent Radio Bearer Reconfiguration Complete to the network.

10:38:34.751 RRC UL.DCCH radioBearerReconfigurationComplete

//device has not received L2Ack from the network for radio bearer reconfiguration complete message.

10:38:34.757 10:38:34.729845 NAS GMM ROUTING AREA UPDATE REQUEST

10:38:40.577 1130104248 Unrecoverable error [RbId=2, Pdu=0]

10:38:40.577 1130104248 CURLC_STATUSDLLL_IND (0)

//Device has initiated Cell update with cause RLC0unrecoverable error (6).

10:38:45.003 1134560668 cellUpdate

u-RNTI

srnc-Identity: 0030

s-RNTI: 02a410

.... ..1. am-RLC-ErrorIndicationRb2-3or4: True

.... ...0 am-RLC-ErrorIndicationRb5orAbove: False

cellUpdateCause: rlc-unrecoverableError (6)

// Device has received RRC Connection Release with cause directed signaling connection re-establishment from the network.

10:38:45.271 1134790283 rrcConnectionRelease

releaseCause: directedsignallingconnectionre-establishment

*Conclusion:*

*Call was dropped on the device because it has not received L2Ack from the network for Radio bearer reconfiguration complete message from the network side.*

### 5.1.5 Logs Analysis to Problem Referred in 4.1.5

Case 5: Call Drop Due To Network Disconnect Command

Purpose: To show voice call dropped on device due to channel release message sent by the network side with cause / Abnormal release

Problem Scenario:

Make Call on IVR or any other test number

*Basic Information:*

Cell Identity - CI (49084), RAT: 2G

*Analysis results:*

//The DUT is latched in GSM cell. Channel release is received from network.

The network conditions are bad. Abnormal channel release received from network with reason "RR cause value: Abnormal release, unspecified (1)".

The REF device is in 2G but in different cell.

10:57:55.457939 RR Channel CHANNEL RELEASE

RR Cause

RR cause value: Abnormal release, unspecified (1)

Cell Selection Indicator after Release of all TCH and SDCCH

//The channel quality too was not good and no HO was received.

10:57:55.356132 RR Measurement MEASUREMENT REPORT

Measurement Results

1... .... = BA-USED: 1

.0... .... = DTX-USED: DTX was not used

..00 1001 = RXLEV-FULL-SERVING-CELL: -102 <= x < -101 dBm (9)

0... .... = 3G-BA-USED: 0

.0... .... = MEAS-VALID: The measurement results are valid

RXLEV-SUB-SERVING-CELL: -104 <= x < -103 dBm (7)

.111 .... = RXQUAL-FULL-SERVING-CELL: BER > 12.8%, Mean value 18.10% (7)

.... 110. = RXQUAL-SUB-SERVING-CELL: 6.4% <= BER < 12.8%, Mean Value 9.05% (6)

.... ...1 00... .... = NO-NCELL-M: 4 neighbour cell measurement result (4)

..01 1101 = RXLEV-NCELL: 29

0100 0... = BCCH-FREQ-NCELL: 8

.... .000 000. .... = BSIC-NCELL: 0

...0 1101 1... .... = RXLEV-NCELL: 27

.000 01... = BCCH-FREQ-NCELL: 1

.... ..10 1100.... = BSIC-NCELL: 44

.... 0110 00... .... = RXLEV-NCELL: 24

..00 000. = BCCH-FREQ-NCELL: 0

.... ...0 1110 1... = BSIC-NCELL: 29

.... .010 100. .... = RXLEV-NCELL: 20

...0 0100 = BCCH-FREQ-NCELL: 4

1011 00.. = BSIC-NCELL: 44

*Conclusion:*

*Call was dropped on the device because Channel release is received from network.*

### 5.1.6 Logs Analysis to Problem Referred in 4.1.6

Case 6: Call Drop Due To No Handover Command From Network

Purpose: To show the call drop occurred on the device because BSS is not sending physical information corresponding with handover command

Problem Scenario:

MO call dropped during mobility test.

*Basic information:*

ARFCN: 58

*Analysis Results:*

UMTS 2 GSM handover was triggered on the strongest available neighbouring cell.

13:05:04.734 RRC DL.DCCH measurement Control

13:05:06.441 UPHY_IRAT Cell No 15, Bsic 13, Bcch Arfcn 58, RxLev 33, OTD 1956, Bsic 1

13:05:06.441 UPHY_IRAT Cell No 16, Bsic 13, Bcch Arfcn 60, RxLev 32, OTD 1806, Bsic? 1

13:05:06.444 RRC UL.DCCH measurementReport

GSM-MeasuredResults

gsm-CarrierRSSI: 84 [bit length 6, 2 LSB pad bits, 1000 01.. decimal value 33]

bsicReported: verifiedBSIC (0)

verifiedBSIC: 15

Item 1

GSM-MeasuredResults

gsm-CarrierRSSI: 80 [bit length 6, 2 LSB pad bits, 1000 00... decimal value 32]

bsicReported: verifiedBSIC (0)

verifiedBSIC: 16

13:05:07.042   RRC   DL.DCCH   handoverFromUTRANCommand-GSM
Cell Description
..01 0... = NCC: 2
.... .011 = BCC: 3
BCCH ARFCN (RF channel number): 58
During U2G handover, UE hasn't received Physical Information message from network. DL channel conditions are fine, but CCI was detected at that time. For UL, UE used max TX power to send access burst, and power detect value was also fine.
*Conclusion:*
*U2G handover failed because network didn't send physical information msg.*
*DL channel condition was fine, and UE used max transmission power for access burst. No UE issue was found. It seem to be UL interference or temporary NW issue.*

### 5.1.7 Logs Analysis to Problem Referred in 4.1.7

Case 7: Drop Due To Invalid Handover Command from Network
Purpose: To show that the call dropped on the device because it has received invalid handover command having ARFCN which was not reported by the device in measurement report
Problem Scenario:
Make Call on IVR.
*Basic Information: RAT: 3G*
Analysis Results:
UE sends event 3a to NW. It contains CELL ID 0 which has best GSM ARFCN 52.
NW replaces CELL ID 0 having ARFCN 52 with CELL ID 0 having ARFCN 61.
Soon after GSM cell list modification, NW provides U2G CS HO to UE.
The strange thing is that NW asks UE to move to ARFCN 61 instead of ARFCN 52.
ARFCN 61 is not reported at all. It must be a NW issue.
11:48:20.771 271117376
CUPHY_GSM_EVENTBASED_GSM_MEASUREMENT_IND (0, 3)
numOfGsmCells :32
gsmCellResultsArray [26]

cellNo: 0

cellId

bsic

networkColourCode3BitString :0

baseStationColourCode3BitString :5

bandIndicator: 0 Asn_dcs1800BandUsed

bcchArfcn: 52

rssi: 47

isBsicVerified: TRUE

11:48:20.780 271127904 measurementReport

eventID: e3a

verifiedBSIC: 0

11:48:22.500 272860784 measurementControl

removedInterRATCellList: removeSomeInterRATCells

InterRATCellID: 0

newInterRATCellList: 11 items

bcch-ARFCN: 61

11:48:22.605 272940435 handoverFromUTRANCommand-GSM

Cell Description

..00 1... = NCC: 1

.... .011 = BCC: 3

BCCH ARFCN (RF channel number): 61

*Conclusion:*

*Call was dropped on the device because device has received invalid handover command to the ARFCN which has not reported by the device in measurement report.*

### 5.1.8 Logs Analysis to Problem Referred in 4.1.8

Case 8: Call Drop Due To Inability To Handle Device Broadcast Message

Purpose: To show that service provider is not able to handle message broadcasted by handset of network capability

Problem Scenario: Make a call to IVR number or any other number

*Basic Information: RAT: 3G*

The problem scenario is as follows.

NW asks EUTRA capability to UE through rrcConnectionSetup.

URLC SDU size becomes 6056 bits since EUTRA capability is too heavy. EUTRA capability includes LTE CA and supported band information.

URLC SDU is split to 48 PDUs. It takes 1.92 seconds purely based on 40ms TTI (Transmission Time Interval) to send them through rrcConnectionSetupComplete even if we don't have any uplink retransmission.

Due to this heavy EUTRA capability, too many PDUs are sent to NW. Meanwhile, NW processing for MR (Measurement Report) seems to be too late. Sometimes, NW doesn't respond to any MR.

By this late MR processing or no response in a NW side, UE falls into a weak signal condition or causes uplink max retransmission.

*Analysis results:*

15:12:31.091 3155937120 EXTENDED SERVICE REQUEST

15:12:31.189 3156020220 rrcConnectionRelease

redirectedCarrierInfo: utra-FDD

utra-FDD: 10833

15:12:31.918 3156715776 CM SERVICE REQUEST

15:12:32.097 3156895983 rrcConnectionRequest

// NW asks EUTRA capability to 3G UE through rrcConnectionSetup.

15:12:32.305 3157161333 rrcConnectionSetup

systemSpecificCapUpdateReqList: 2 items

SystemSpecificCapUpdateReq-r8: gsm

SystemSpecificCapUpdateReq-r8: eutra

// UE sends EUTRA capability to NW through rrcConnectionSetupComplete which consists of 48 PDUs.

15:12:32.597 3157384874 rrcConnectionSetupComplete

15:12:32.597 3157384905 AM Mode: New SDU being submitted for segmentation New Buffer Occupancy -6056, New SDU Size - 6056, RbId 2, Mui 513, SduIdentifier 0

15:12:32.602 3157390429 URLC UL Data: RbId=2, MODE_AM, RlcH=8000, BitSize=144, PollBit=0, VT_A=0, VT_S=1, Sn=0:

15:12:32.607 3157400408 URLC UL Data: RbId=2, MODE_AM, RlcH=8008, BitSize=144, PollBit=0, VT_A=0, VT_S=2, Sn=1:

15:12:32.610 3157410387 URLC UL Data: RbId=2, MODE_AM, RlcH=8010, BitSize=144, PollBit=0, VT_A=0, VT_S=3, Sn=2:

15:12:33.011 3157840349 URLC UL Data: RbId=2, MODE_AM, RlcH=816c, BitSize=144, PollBit=1, VT_A=0, VT_S=46, Sn=45:

15:12:33.016 3157850389 URLC UL Data: RbId=2, MODE_AM, RlcH=8174, BitSize=144, PollBit=1, VT_A=0, VT_S=47, Sn=46:

15:12:33.019 3157860369 URLC UL Data: RbId=2, MODE_AM, RlcH=817d, BitSize=144, PollBit=1, VT_A=0, VT_S=48, Sn=47:

// NW doesn't respond to measurementReport sent by UE so that UE can't do handover.

// in the end, UE falls into a weak signal condition.

15:12:54.639 3179442522 measurementReport

15:12:54.642 3179450518 URLC UL Data: RbId=2, MODE_AM, RlcH=8680, BitSize=144, PollBit=0, VT_A=177, VT_S=209, Sn=208:

15:12:54.669 3179490557 URLC UL Data: RbId=2, MODE_AM, RlcH=8688, BitSize=144, PollBit=0, VT_A=177, VT_S=210, Sn=209:

15:12:54.724 3179530504 URLC UL Data: RbId=2, MODE_AM, RlcH=8694, BitSize=144, PollBit=1, VT_A=177, VT_S=211, Sn=210:

15:12:54.947 3179770555 PDU RETRANSMITTED [RbId 2, PduSn 209, VT_DAT 2, HFN 0, VT_A 177, VT_S 212]

15:12:55.146 3179970568 PDU RETRANSMITTED [RbId 2, PduSn 209, VT_DAT 3, HFN 0, VT_A 177, VT_S 212]

15:12:57.953 3182770647 PDU RETRANSMITTED [RbId 2, PduSn 209, VT_DAT 10, HFN 0, VT_A 177, VT_S 234]

15:12:58.669 3183490618 PDU RETRANSMITTED [RbId 2, PduSn 209, VT_DAT 11, HFN 0, VT_A 177, VT_S 240]

// At the trouble time, a channel condition is good enough and UE has 0% BLER.

// It means that it's not an UE issue but a NW issue.

15:12:59.368 3184190905 [RX DIV] refRlNr 1, fingersStr 0x5454, lockedFingers 3, Converted Rake Energy 3217, Real Rake Energy 28964, rake Ec/Io -6 [dB], RSCP -71 [dBm]

15:12:59.369 3184191393 txPower -220 pdPower -100 pdValue 844001280 txSPI 0x55c47bf0 rfTxSPI 0x0 dgc 777 hs_offset 4096

15:12:59.436 3184251146 DLPC: sirAvg_dB = 8051, target_sir_dB =6369, sirInSlot_dB = 6859, RSCP=352836, ISCP=22654, ulTpcRd =0x6800,

15:12:59.443 3184261614 Framework Cfn 111 Urrc Trch id 1 has received 511 good crcs and 0 bad crcs, BLER [%] = 0.0000

15:12:59.443 3184261644 Framework Cfn 111 Urrc Trch id 2 has received 511 good crcs and 0 bad crcs, BLER [%] = 0.0000

15:12:59.443 3184261644 Framework Cfn 111 Urrc Trch id 3 has received 511 good crcs and 0 bad crcs, BLER [%] = 0.0000

15:12:59.443 3184261644 Framework Cfn 111 Urrc Trch id 24 has received 255 good crcs and 0 bad crcs, BLER [%] = 0.0000

*Conclusion:*

*Solution in NW side is to upgrade NW SW to accommodate heavy EUTRA capability.*

### 5.1.9 4 Logs Analysis to Problem Referred in 4.1.9

Case 9: Call Drop Due To Network Bts Timing Advance Error

Purpose: To show that the call drop occurred on the device because of handover failure resulted due to timing advance out of the range (Target BTS is beyond normal range)

Problem Scenario:

Make Call on IVR.

*Basic Information*: RAT: 2G, Cell Info: Active Set: PSC 70 UARFCN 10807

IMSI: 404 100603443063

*Analysis Results:*

// Network has send Handover command to the device.

15:01:04.521 RR HO HANDOVER COMMAND

Cell Description

..10 1... = NCC: 3

.... .110 = BCC: 2

BCCH ARFCN (RF channel number): 57

//HO failure resulted due to timing advance out of range (target BTS is beyond the normal range).

15:01:04.554

MPH_HANDOVER_IND/HANDOVER_OUT_OF_RANGE

// which result in irat handover failure. Inter rat Handover failed

*Conclusion:*

*Call was dropped on the device because BTS timing advance out of range.*

### 5.1.10 Test Results Post Service Provider Fixes

| S. No | Handset Manufacturer | Quantity | Model Name | Call Processor |
|---|---|---|---|---|
| 1 | Samsung | 2 | Galaxy S5 / I9500 | Qualcomm Based |
| 2 | Apple | 2 | IPhone 6+ | Apple Proprietary |

| S. No | Details | Duration |
|---|---|---|
| 1 | Test Duration | May 2016 |
| 2 | Total number of calls made in Samsung Device | 500 |
| 3 | Total number of calls made in Apple Device | 500 |
| 4 | Total call dropped in Samsung device | 20 [ 4 % ] |

| S. No | Total call drops breakup in terms of network side issue's | | |
|---|---|---|---|
| | Total Call drops | 20 | % |
| 1 | BTS Timing Advance | 0 | 0 |
| 2 | Handset capability | 0 | 0 |
| 3 | Invalid Handover | 2 | 10 |
| 4 | Radio Link Failure | 8 | 40 |
| 5 | Channel Release | 2 | 10 |
| 6 | High Interference | 4 | 20 |
| 7 | Network Initiated | 2 | 10 |
| 8 | Device Issue | 2 | 10 |

**Table 6 : Test Results Post Service Provider Fixes**

From table 6 we can easily deduce that service provider has improved their side and no call drop failure occurred due to Timing advance error and Handset capability issue. In Second round of testing total call tested are 500 each for Samsung device and competition device other factors has no improvement from service provider

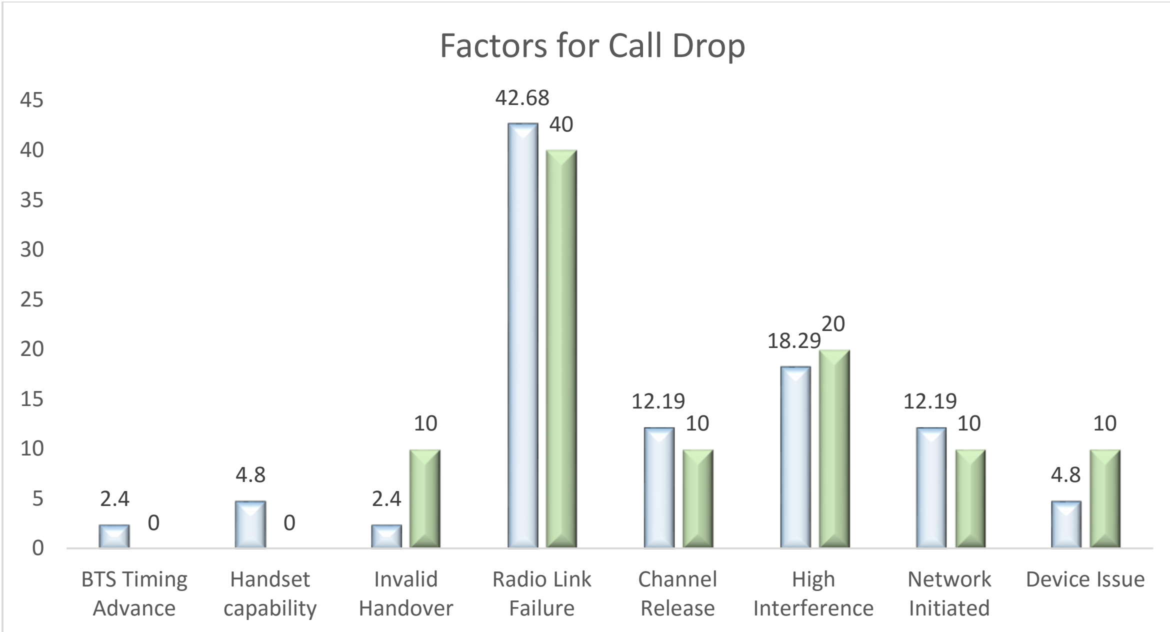


**Figure 14 : Comparison between before and after the improvement has been done by service provider**

| Failure Case | Details | Log Analysis | Figure |
|---|---|---|---|
| Case 1 | Handover Failure Scenario | 5.1.1 | Figure 7 |
| Case 2 | Channel Release by Network | 5.1.2 | Figure 8 |
| Case 3 | Radio Link Failure | 5.1.3 | Figure 9 |
| Case 4 | RRC Connection Release | 5.1.4 | Figure 10 |
| Case 5 | Disconnect Instruction from Network Side | 5.1.5 | Figure 11 |
| Case 6 | No Handover Command Received | 5.1.6 | Figure 12 |
| Case 7 | Invalid Handover Command | 5.1.7 | Figure 13 |
| Case 8 | Network Inability to Handle Handset Broadcast Message | 5.1.8 | No Figure |
| Case 9 | BTS Timing Advance Error | 5.1.9 | No Figure |

**Table 7 : Reference table for quick review of all related work in thesis**

# Chapter 6: Conclusion and Future work

Conclusion: We have compared test results of both the test cycles and after checking cause and logs analysis further it can be concluded that service providers has improved network for few of the issue's which is acknowledged based upon the logs and analysis shared. Basically all the service providers can be categorized into 7 types. Majority of the issues are due to spectrum size limitation as well as poor RF planning from network side.

to improve further service providers need to invest heavily on the infrastructure or they can further can have contract with other service provider in the same telecom circle for spectrum sharing eventually providing customers good Quality of Service

Failure cause from Case 1 to Case 6, Service is provider is well aware of the situation and is trying to further improve network condition various factors which are:-

- Limited Spectrum
- Congestion control mechanism
- Investment required for upgrading infrastructure
- Network side policy/ trade-off between quality and throughput

Failure Case 8 is acknowledged by the Service provider and relevant software solution / upgrade is already completed, also during drive conducted after the solution upgrade from the service no such issue is again captured in the failure logs

Failure Case 9 is acknowledged by the Service provider and relevant software solution / upgrade is already completed, also during drive conducted after the solution upgrade from the service no such issue is again captured in the failure logs

**Future Scope**: For failure Case 7[Drop Due To Invalid Handover Command from Network] Service provider has agreed for joint test to identify the invalid handover command from the network side and if reproduce then fix it

## *References*

[1]P. Stuckmann, *The GSM evolution*. Chichester, West Sussex, England: J. Wiley, 2003.

[2]S. Das, *QoS issues in wireless mobile multimedia*. Norwell, Mass. [u.a.]: Kluwer, 2003.

[3]W. Zhao, *Handover techniques and network integration between GSM and satellite mobile communication systems*. University of Surrey, 1997.

[4]"Reduced Call Drop Rate in a 4G Network using Vertical Handoff Algorithm", *IJSR*, vol. 5, no. 2, pp. 715-718, 2016.

[5]"Home: Telecom Regulatory Authority of India", *Trai.gov.in*, 2016. [Online]. Available: http://www.trai.gov.in. [Accessed: 27- Jul- 2016].

[6]A. Wilfred and A. Theophilus, "Investigation of Call Drop in a Cognitive GSM Network", *Communications on Applied Electronics*, vol. 3, no. 5, pp. 12-17, 2015.

[7]R. van Nobelen, N. Seshadri, J. Whitehead and S. Timiri, "An adaptive radio link protocol with enhanced data rates for GSM evolution", *IEEE Pers. Commun.*, vol. 6, no. 1, pp. 54-64, 1999.

[8]V. Manelis, I. Kaioukov and A. Novikov, "Identification and analysis of interference effects of GSM base stations", *Radioelectron.Commun.Syst.*, vol. 52, no. 2, pp. 55-62, 2009.

[9]J. Acharya, L. Gao and S. Gaur, *Heterogeneous networks in LTE-Advanced*. 1996

[10]A. Perez, *Mobile networks architecture*. London: ISTE, 2012.